An Analysis of Water Management for a PEM Fuel Cell System in Automotive Drive Cycles

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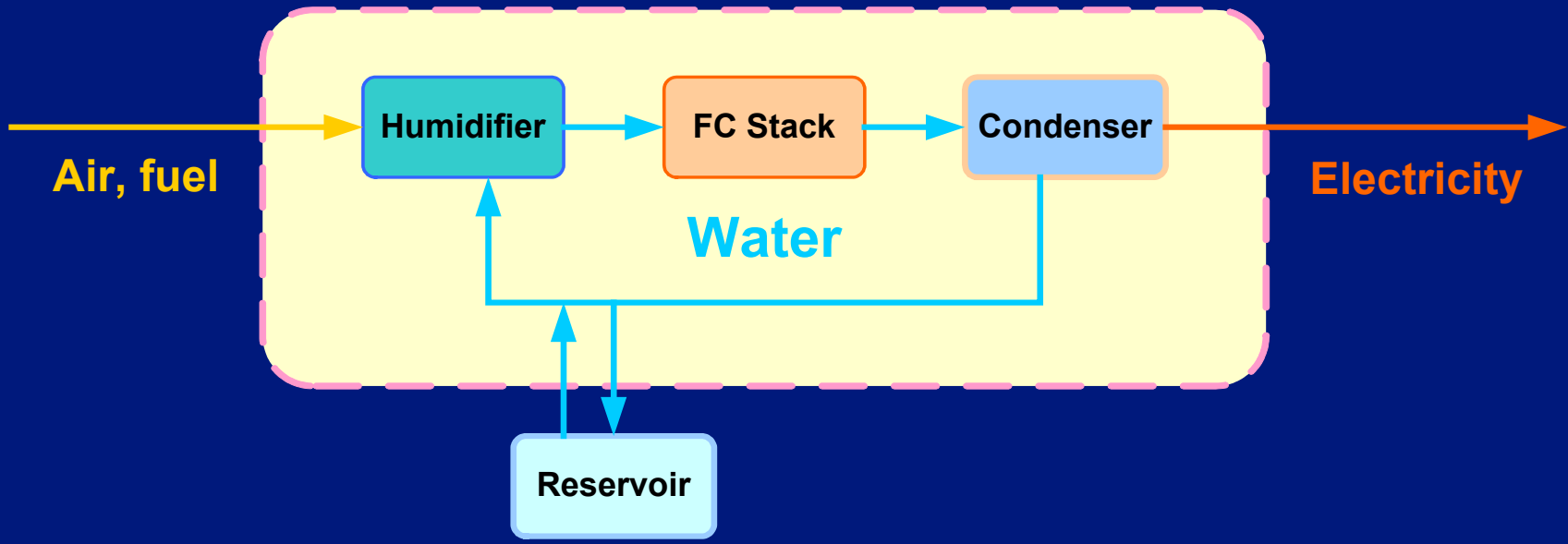
Outline

- Introduction
- Vehicle Specifications and Fuel Cell System Model Overview
- Results
- Conclusions

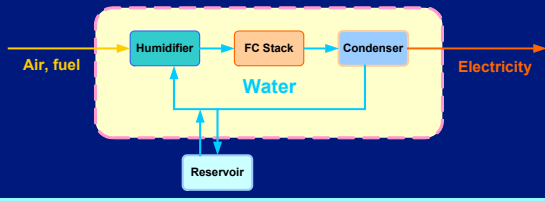
Water Balance



- Neutral water balance:

Water needed for humidification	=	Water produced at the cathode	+	Water condensed out of the exhaust

Problem Statement



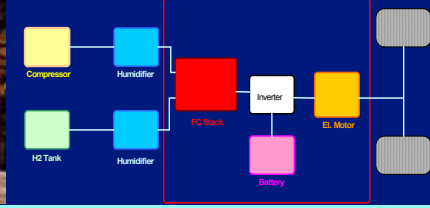
- Under no conditions have water deficiency

Condenser or water reservoir **size**
needs to be large enough
for both **cold** and **hot** start conditions in drive cycles

In this study:

- System parameters
  - –condenser size, rel. humidity requirements of the cathode inlet gas
- Vehicle parameters
  - –cold and hot start, drive cycles

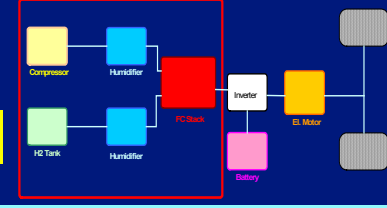
Baseline Components



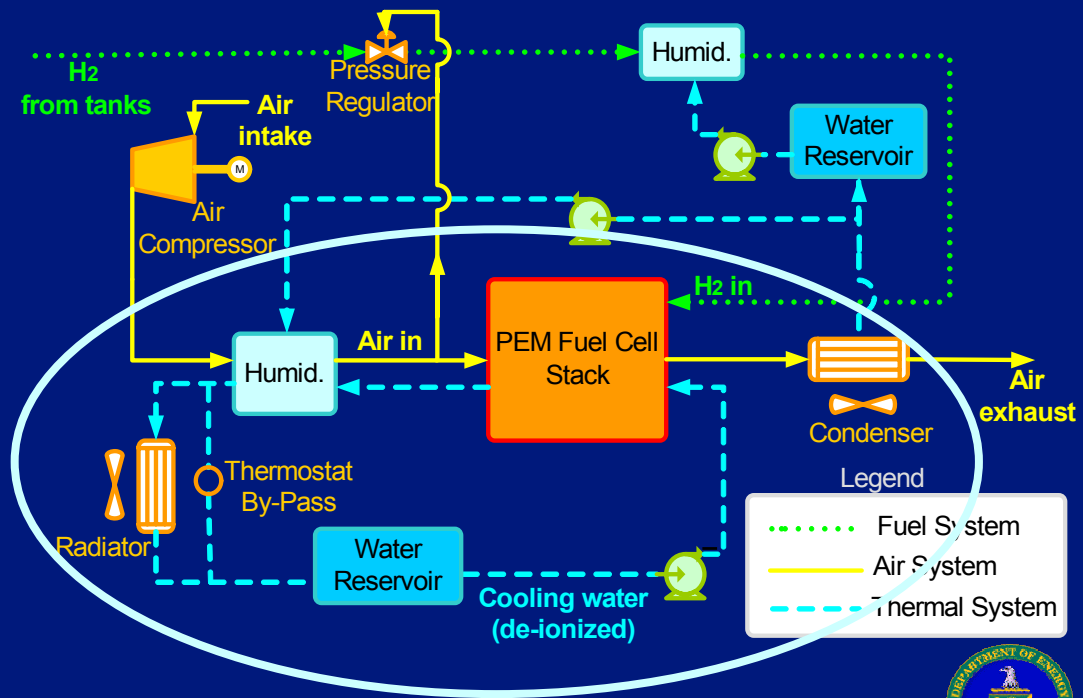
Based on
a mid-size SUV similar to Jeep Grand Cherokee

Component	Description
Fuel Converter	50 kW pressurized fuel cell system, Virginia Tech
Motor/Controller	117 kW AC induction motor developed by Virginia Power Technologies
Energy Storage System	12 Ah Li-ion battery pack

Virginia Tech Fuel Cell System Model



- Semi-empirical, transient
- Thermal model for ADVISOR to evaluate:
  - –Hot & cold start vehicle fuel economy
  - –Power limitations due to temperature
  - –Water balance for reactant humidification
- Polarization curve based on Honeywell stack
- Compressor data (map from Opcon Autorotor)

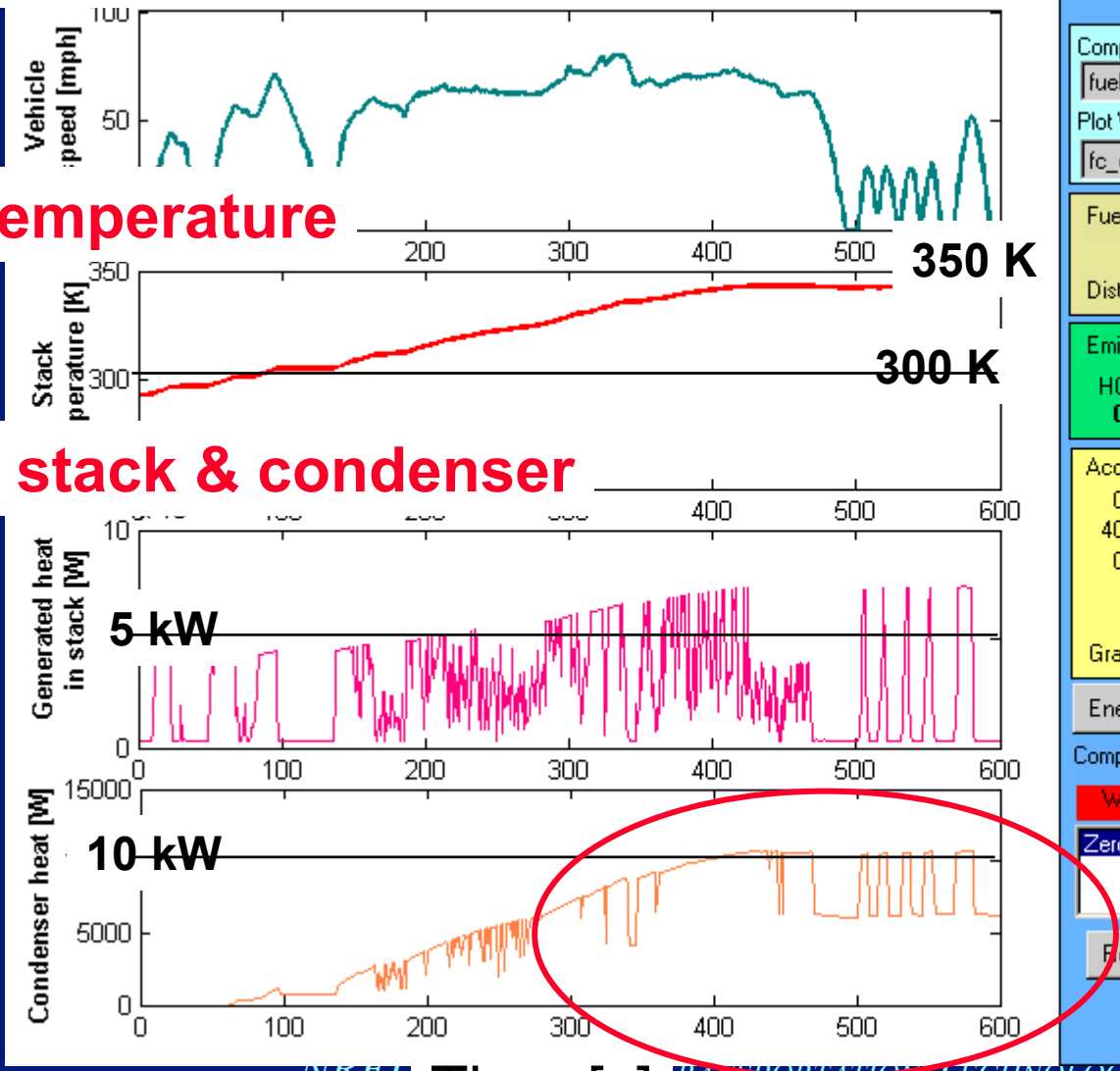


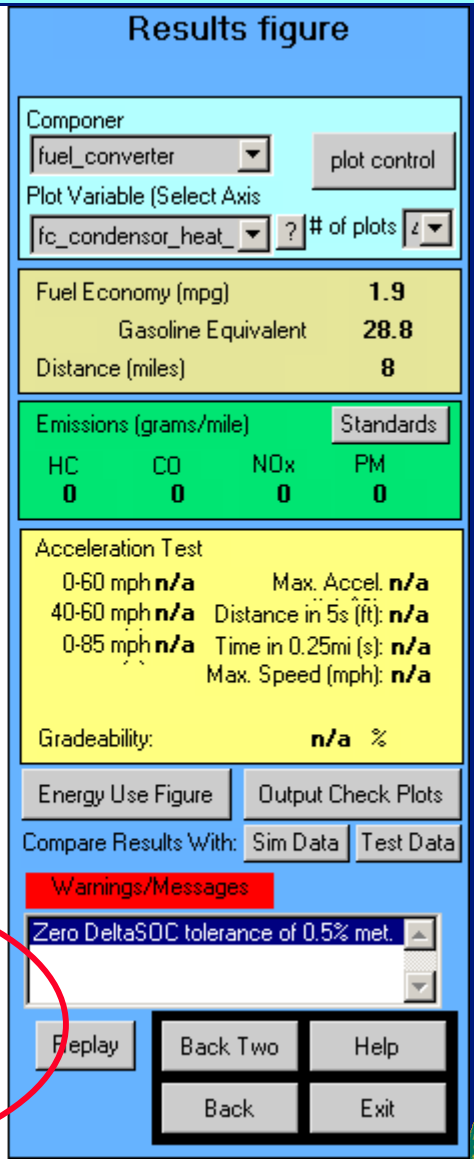
Example of ADVISOR Output: US06, Cold Start & Small Condenser, 0.35 m^2

Vehicle speed

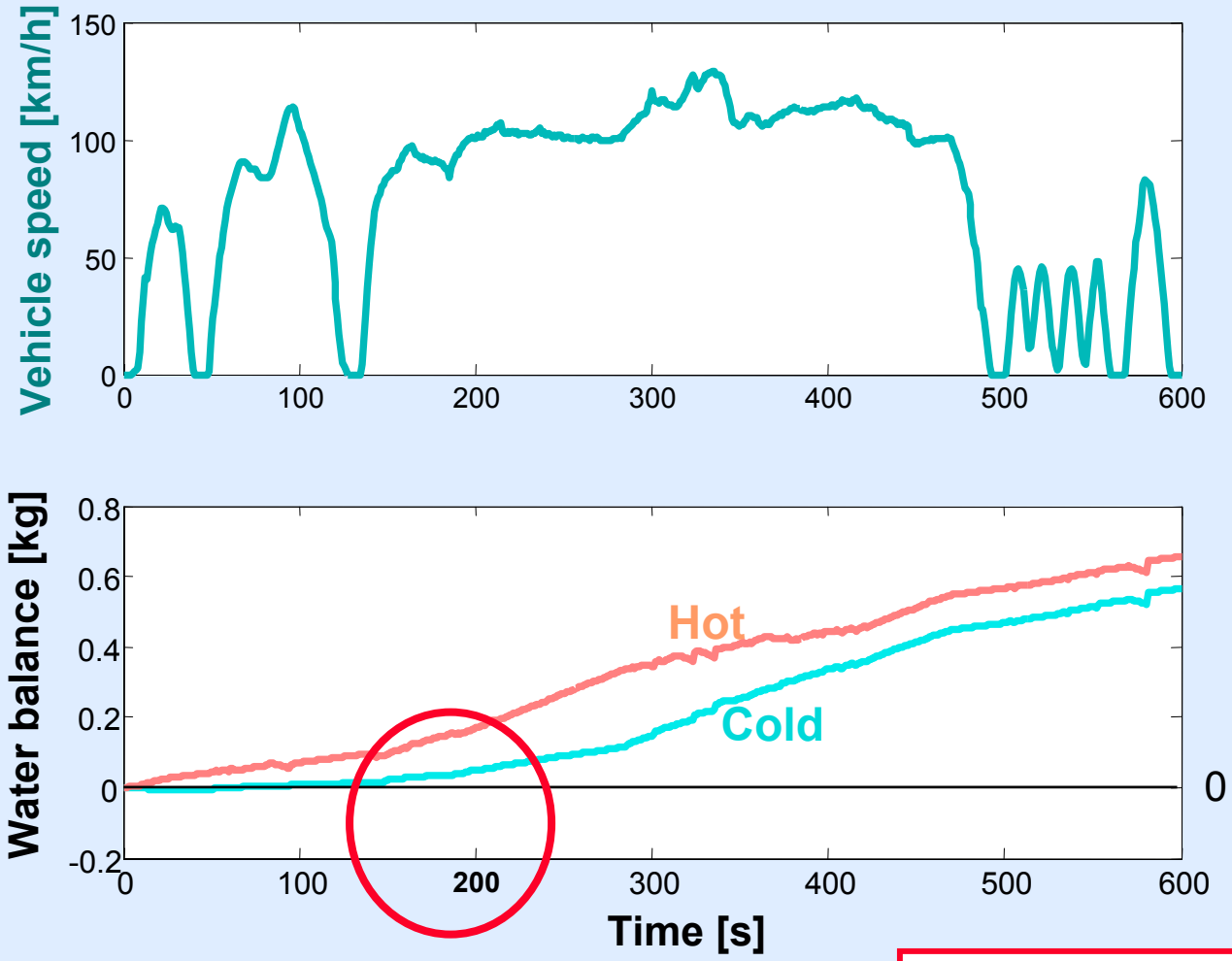
Stack temperature

Heat in stack & condenser



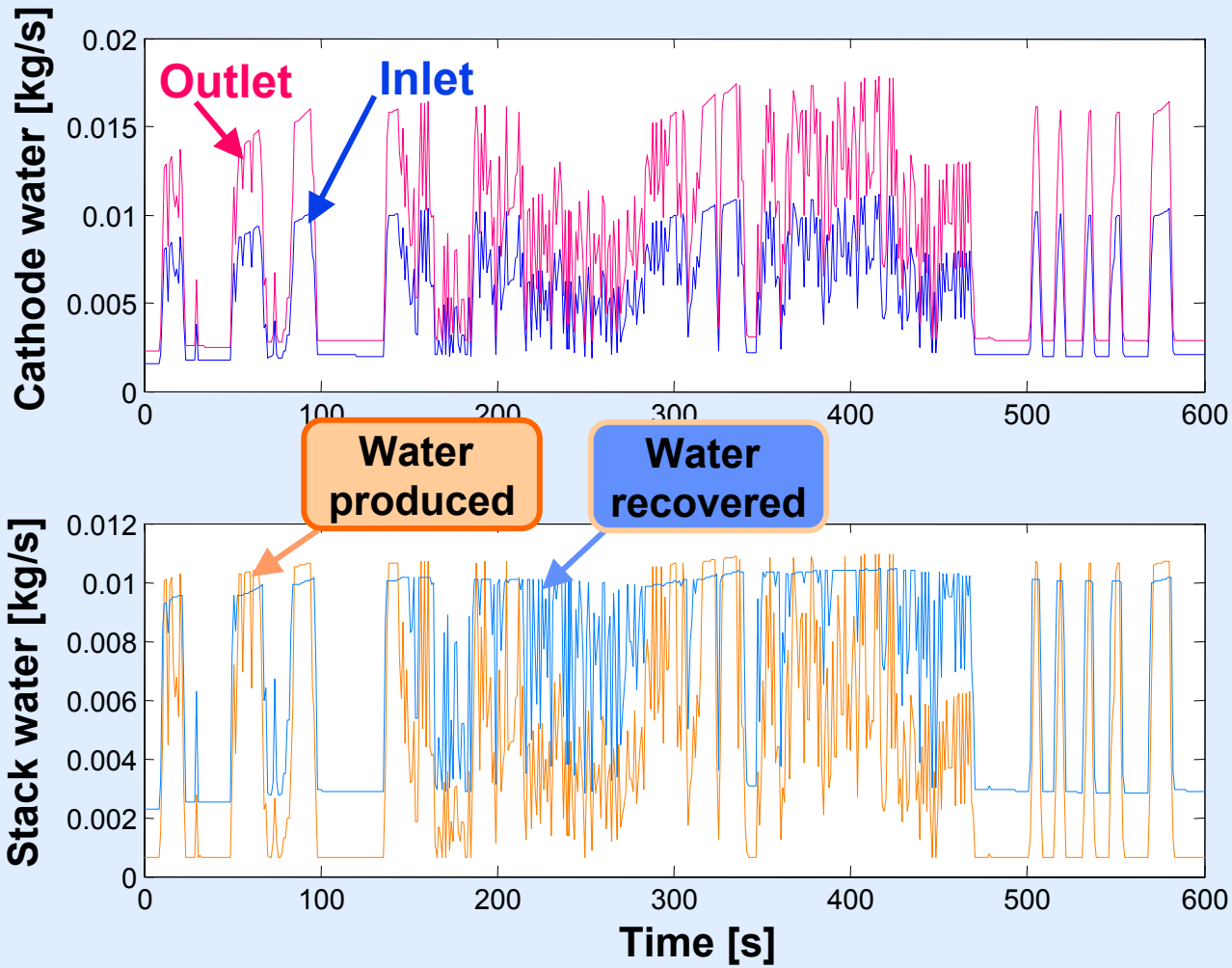


The US06:
Hot & Cold Start, Water Management



Cold start:
positive WB after warm-up time

The US06: Hot Start, Water Management



Water needed for humidification

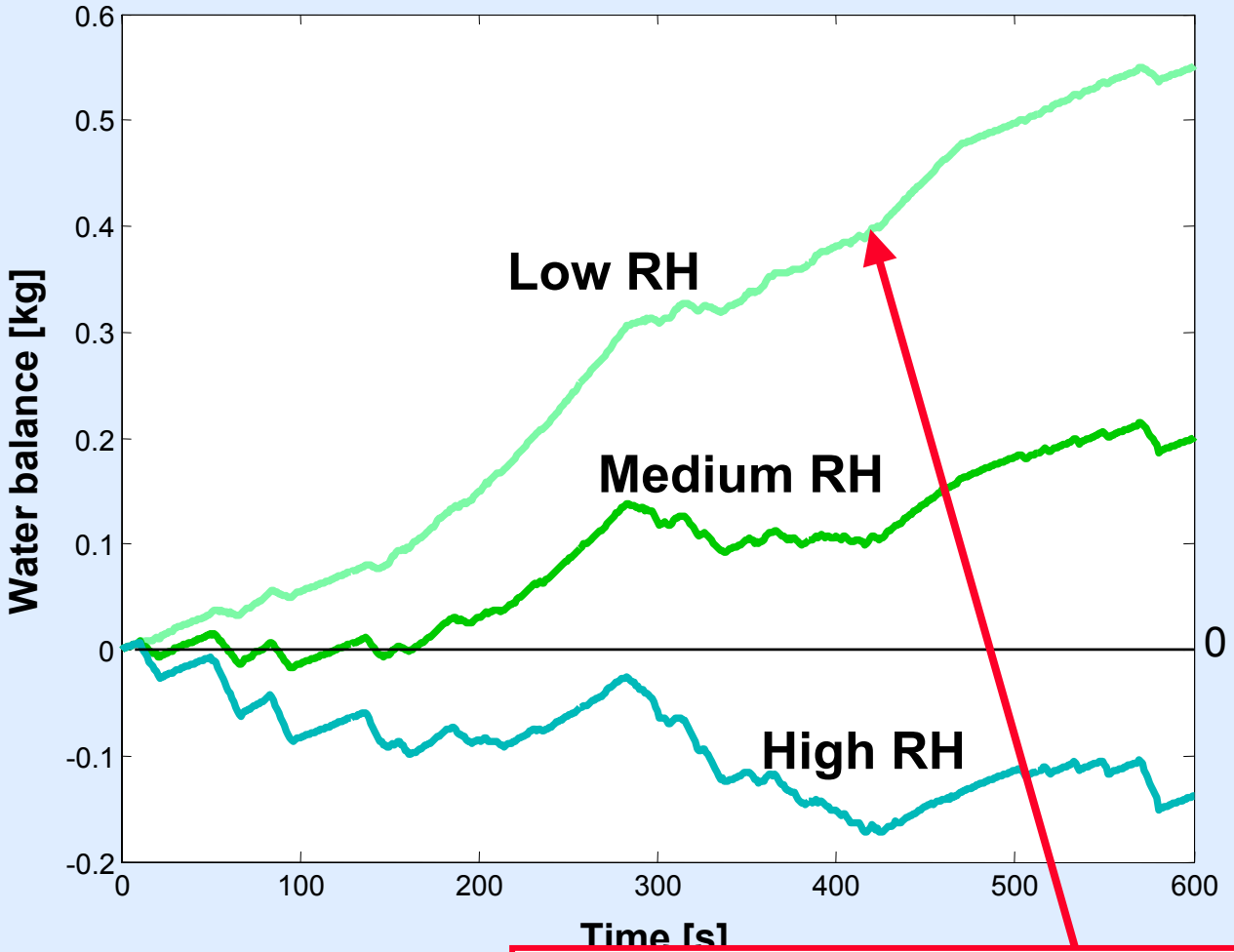
=

Water produced at the cathode

+

Water condensed out of the exhaust

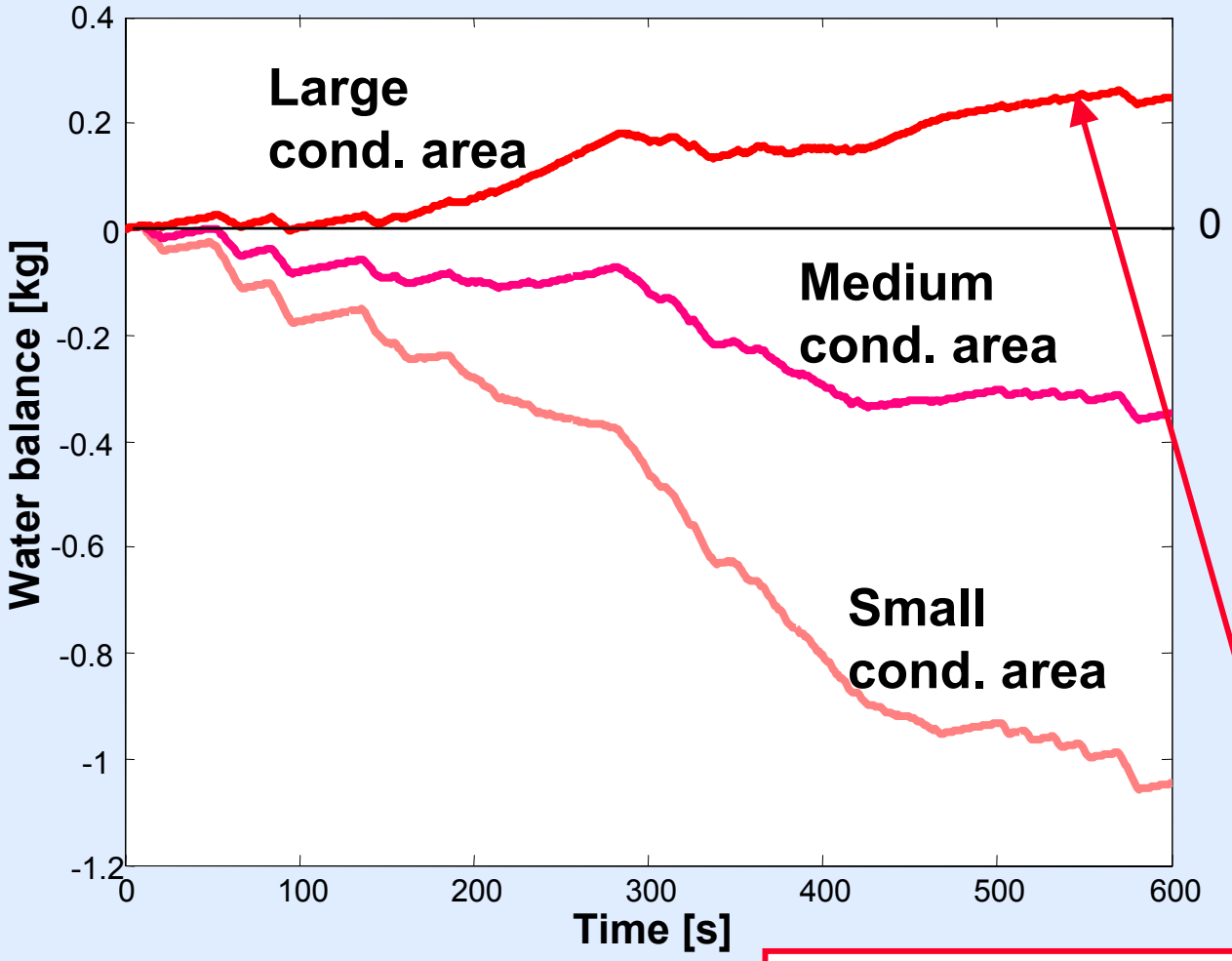
Sensitivity to the Cathode Inlet Humidity Requirements



US06
Hot start

Positive WB at low rel.humidity requirements, RH=30%

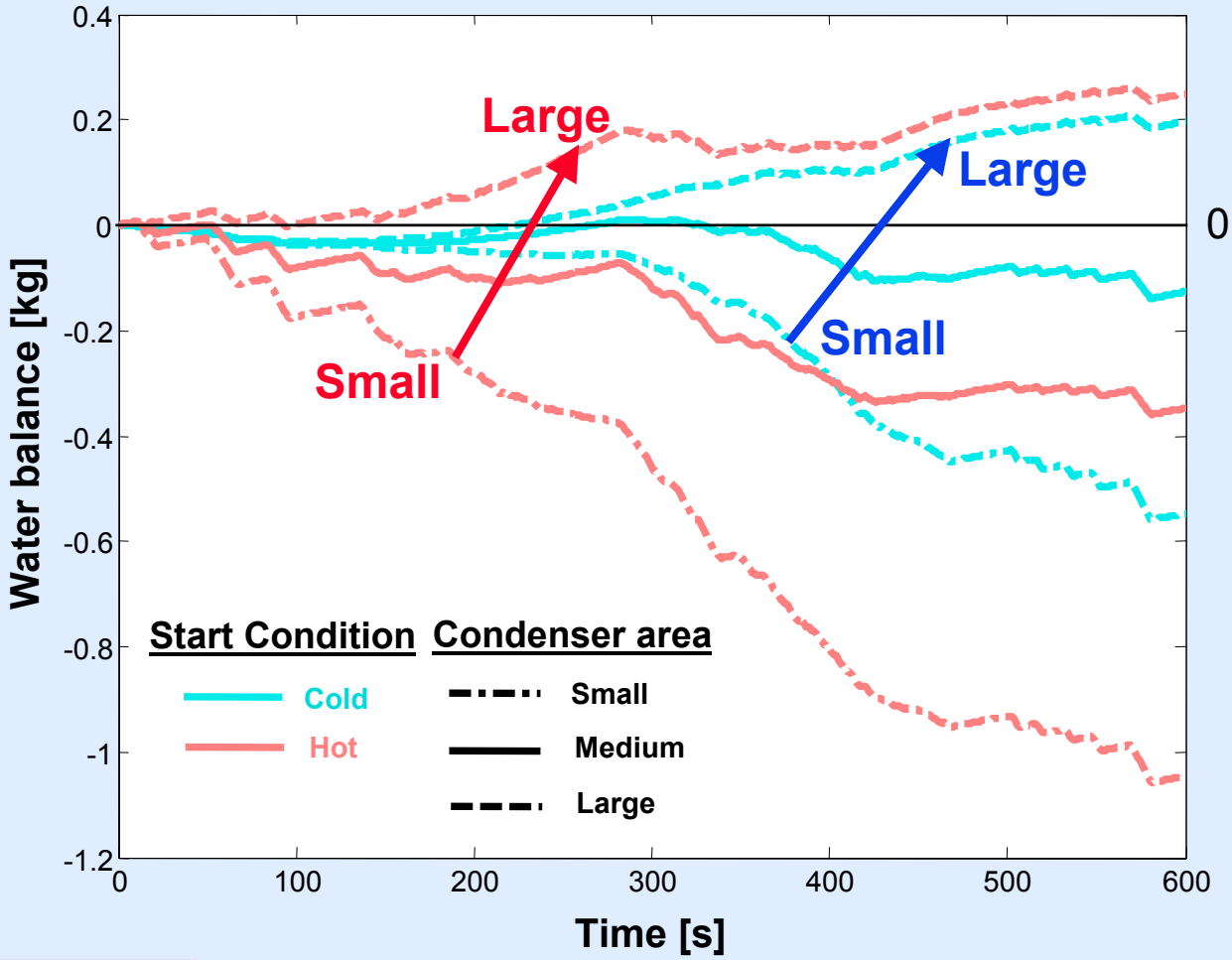
Sensitivity to the Condenser Area



US06
Hot start

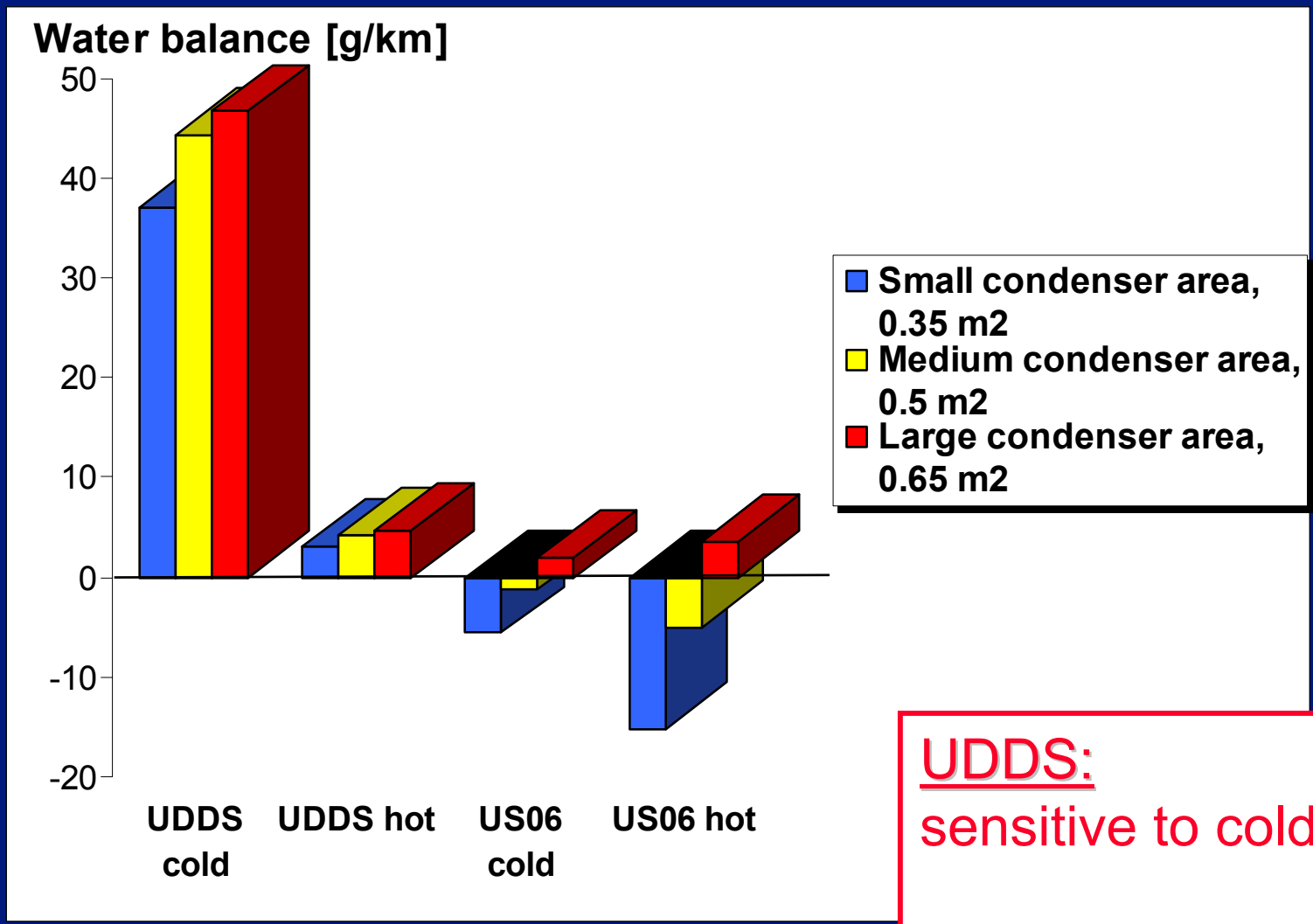
Positive WB at large condenser area
Acond, 0.65 m^2

The US06: Sensitivity of the Condenser Area for Cold & Hot Start



Better WB at
low temperature operation

Cold/Hot Start and Condenser Area Impact in UDDS and US06 Cycles



UDDS:
sensitive to cold/hot start

US06:
sensitive to size of condenser

Conclusions

- Demonstrated fuel cell hybrid vehicle simulation tool with thermal and transient properties
- Aggressive drive cycle
  - more sensitive to condenser area than cold/hot start
  - need a large condenser to ensure positive water balance for both cold and hot start conditions.
  - or, if a small condenser is used, a large water reservoir will be necessary.
- Urban drive cycle
  - more sensitive to cold/hot start than condenser area

Conclusions cont'd

- Important to look on the water balance during the **entire** cycle rather than the average value
  - the water balance may be occasionally negative but regain a positive balance by the end of the cycle.
- Low temperature operation may have a beneficial impact on the water balance.
- The water balance is favored by low relative humidity requirements of the cathode inlet gas.